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Multiple Criteria Choice of the Health Insurance in China Market

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1. Introduction
2. Analysis of China Insurance Market
3. Multiple Criteria Decision-Making Methods Description
4. Application of Multiple Criteria Choice of the Health Insurance Products
5. Conclusion

Bibliography
List of Abbreviations
Declaration of Utilization of Results from the Diploma Thesis
List of Annexes
Annexes

References:

EVANGELOS, Triantaphyllou. *Multi-Criteria Decision Making Methods: A Comparative Study.* Berlin: Kluwer Academic Publishers, 2000. 318 p. ISBN 0-792-36-607-7.
SATTY, Thomas L. and L. VARGAS. *Fundamentals of Decision Making and Priority Theory With the Analytic Hierarchy Process.* 1st ed. Pittsburgh: RWS Publications, 1994. 527 p. ISBN 97B-0-9620-3176-2.
TZENG, Gwo-Hshiung and Huang JIH-JENG. *Multiple Attribute Decision Making: Methods and Applications.* London: Chapman & Hall/CRC, 2011. 349 p. ISBN 1-439-B6-157-9.

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The declaration

“Here with I declare that I elaborated the entire thesis, including all annexes, independently.”

Ostrava dated 11.07.2014

Liu Tao

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1. Introduction

Decision making is very normal in our daily life, when we need to decide the laptop to buy, to determine the cloth to wear, or to choose the business partner. We will always need to make decisions. The multiple choice decision-making (MCDM) happens when we face many criteria to choose, with several alternatives. We can't decide which one is better for us, just considering one criterion of the alternative. When we face MCDM problems, we need some specific method to help us determine the best alternative.

The objective of this diploma thesis is to choose the best alternative from health insurance products in China, according to the multiple choice decision-making methods. In order to do so, we picked three health insurance products from three different life insurance companies in China, and determined the possible criteria. The method we applied for MCDM problems are: Analytic hierarchy process (AHP) method, Simple additive weighting method (SAW), VIKOR method, and TOPSIS method.

There is, in the first part, China insurance market description. It means the introduction of the development of China insurance market from old times, the development of the regulatory of China insurance companies over time, China insurance industry in the international position, and also the ratio analysis of China Life Insurance Company Limited (China Life). In the second part, there is the description of the MCDM methods. We will introduce 4 methods to reach the goal, each method will have their own way of calculation and idea.

The most important part is when we are applying the methods for a 30 years old man, who is making choice to have a health insurance product. By applying different method, we will get different results. In order to do the decision, we may need to compare the results of each method, and make an average of all. So far, we can choose the best alternative for our customer.

2. Analysis of China insurance market

In this chapter, we will introduce you the situation of China insurance market, including the development of insurance industry in China, the nowadays insurance market position in China, and also the international position of China insurance companies, and so on. Many of the history and data of the development of China insurance market are based on the material of BaiduBaike[1]. The history of China Life is applied from its official website and many of its data are based on the annual report of China Life.

2.1 Insurance industry description

The insurance industry refers to the form of using the capital from contract to compensate insured person's economic profit.

An "insurer" is a company who is selling the insurance. The insured person or entity is the one who is buying the insurance policy. The fee that the insured should pay to the insurer is called "premium". The insurance company will have the responsibility or obligation to pay for the insured person if the one gets some financial lose under the insurance policy, the fee should be paid to the insured person is called "claim". In one insurance policy should be stated the payment of the premium, the insured project and the amount of the claim, that is the contract between insured person and insurer.

We can classify the insurance into two groups: Property Insurance and Life Insurance, according to the insured subject.

Property insurance means the insurance deal with property or its related benefit, including property damage insurance, liability insurance, credit insurance, guarantee insurance, agricultural insurance and so on. It is a kind of compensatory insurance with tangible or intangible property or their related benefit as the insurance subject.

[1] BaiduBaike is not the official database in China, but its record and data are generally acceptable by Chinese residents.

The life insurance is the insurance with human life or their body as the insurance subject. When the insured person get retired, injured, can't work, or died because of accident, illness, or old age, they will receive the claim or annuity from the insurer according to the contract, in order to solve the financial problem. Usually life insurance deal with the problem of death, accident, and health.

2.1.1 The concept of reinsurance

Reinsurance is insurance that is purchased by an insurance company from one or more insurance company, that is, the insurance of insurance. Usually, we call the insurer, who directly makes business with insured person, primary insurer (or original insurer) or primary insurance company. The business he or she made is called primary insurance. Because the ability of an insurance company to take risk is limited, which is limited by the amount of its capital fund and provident fund, the primary insurance company has to manage its underwriting risk responsibility in order to increase its economic profit and competitiveness. The primary insurance company would like to separate the part of business which exceed its ability. The reinsurance company is the insurance company which accepts the separated business.

With the development of reinsurance business, some large primary insurance companies start to do reinsurance business. Many of the insurance companies have business of reinsurance in nowadays.

2.2 The development of regulation of insurance industry in China[2]

China's insurance industry has experience a tortuous developing process. People's Bank of China (the central bank of China) and the Ministry of Finance had different historical periods exercised the functions of regulation of the insurance industry.

[2] The information of the development is based on insurance industry of BaiduBaike.

In October 1949, after the founding of new China, the China Life Insurance Company was founded, and it was led by People's Bank of China. From the latter half of 1950s, the China insurance industry had entered a long period of trough situation. At that time people didn't have the conception of insurance, they thought it was a waste of money to buy insurance. The regulation of insurance also stayed at a poor level without any improvement. In April 1979, our State Council realized the importance of insurance industry and approved some specific laws to recover the insurance industry step by step, at that time China insurance industry was still regulated by People's Bank of China.

In 1985, our state council issued the provision of "Temporary rules for insurance business regulation", it stated that People's Bank of China is the regulator of insurance companies. In 1995, because of the development of the insurance industry in China, the People's Bank of China set up an insurance department to regulate the mid-size insurance companies. At the same year, People's Bank of China strengthened the regulatory of insurance industry, it required to set insurance sectors and specific regulatory staffs at local government.

With the development of banking sector, security businesses, and insurance separate operations, it is more and more difficult for People's bank of China to regulate the whole insurance industry. So in November 1998, our State Council set up the China Insurance Regulatory Commission (CIRC) to specially regulate the insurance companies in China, in order to have a better regulatory in the insurance industry.

In March 2001, the China Insurance Association (CIA) was founded. It is a national non-profit social organization, a self-regulatory organization of China insurance market. From that year on, the regulation of China insurance business was more and more proper and healthy.

2.3 The development of insurance industry in China[3]

Since the Reform and Opening up, the development of China's insurance market has made remarkable achievements. In 1980, the year of recovery of insurance market,

[3] The development is based on insurance industry of BaiduBaike.

the total insurance premium income was only 0.46 billion RMB. After 20 years, in 2000, our insurance premium income reached 159.6 billion RMB, average annual growth rate was 34%. But our insurance market got many questions, in 1999, our premium per person was 110.58 RMB (Insurance Density[4]). At the same year, the insurance density of Switzerland was 4,654.3 dollars, of USA was 2,722.7 dollars, and of Hong Kong was 1,072.8 dollars, the insurance density of China was ranking 82nd at the world position. The percentage of insurance premium income to GDP (Insurance Penetration[5]) was 1.49%, ranking 66th in the world, while the average insurance penetration of developed countries was 10%. The insurance market was almost monopoly by two or three companies, with little competition. The reinsurance market was very weak and the quality of the capital in insurance companies was low.

However from past decade, with the rapid growth of China's economy, continuously improve of national income and steadily increasing of residents insurance consumption, our insurance industry grows very quickly and makes impressive results. According to the China Insurance Regulatory Commission (CIRC) statistic data, China's insurance industry premium increase from 159.6 billion RMB in 2000 to 1722.2 billion RMB in 2013, with an increase of 97.9% though 13 years.[6]

At the end of 2012, there were totally 153 insurance corporations, increased 13 ones comparing to last year, with 1536 insurance corporation branches, increased 66 ones. The 86.9% insurance corporations were located in the east area in China, increased 0.5% comparing to last year. Total capital in insurance industry were 7.4 thousand billion RMB, increased 22.3%. The whole year total insurance premium were 1.5 thousand billion RMB, increased 8.0%, the growth rate decreased a little comparing to last year.[7] The geographical distribution of insurance industry in China of 2012 is shown on Table 2.1.

[4] Insurance density: total insurance premium divided to total population of one area.
[5] Insurance penetration: total insurance premium divided by the GDP of one region.
[6] CIRC 2013 insurance statistic data report: http://www.circ.gov.cn/web/site0/tab5257/info3901864.htm
[7] 2012 China Regional Financial Performance Report

Table 2.1 Insurance industry Geographical distribution at the end of 2012 (%)

	East area	Mid area	West area	East-north area	Total
Insurance companies	86.9	3.3	5.2	4.6	100.0
Insurance company Branches	46.5	18.7	23.8	10.9	100.0
Insurance premium	54.5	19.1	19.0	7.4	100.0
Property insurance premium	55.5	16.6	20.7	7.2	100.0
Life insurance premium	54.0	20.5	18.1	7.5	100.0

Source: 2012 China Regional Financial Performance Report from The People's Bank of China (2014)

In 2012, the Insurance density was 1,144 RMB/person, increased 82 RMB comparing to last year. The insurance penetration was 3.0%, stayed at the same level to last year. The insurance density of Luxembourg was 46,805 USD/person, ranking the first in the world. The USA got 5,757 USD/person; The United Kingdom got 5,144 USD/person, they were ranking 5th and 6th. China's insurance density was just 181 USD/person[8] which is very low, that's because of the large population of China, in China many families in countryside don't have any insurance at all, they don't pay any insurance fee or be insured by any contract, even though there are some statutory insurance. (Many local governments in the countryside don't have enough regulatory of insurance for the people, and many of the people live in countryside don't have the sense of insurance at all, that's very normal in some remote area.)

In 2012, the gross insurance premium of China was 237,717 million USD, ranking 6th all over the world.[9] The market situation of insurance industry in China is not comparable to most developed countries. China insurance industry has developed for about 35 years (from 1980s), it is still a very young market. China gets the world largest population, with the world fourth largest area, it is very hard for our government to deal with the insurance problem with some many people in such short time. China will need more time to develop its regulatory of insurance market and its insurance business.

[8] The exchange rate of RMB to USD in 2012 was 6.31 RMB/USD, according to the information from World Bank Group.

[9] Top 5 countries: United States, 2,279,817USD; European Union (15 countries), 1,390,287USD; Japan 465,339USD; United Kingdom, 366,582USD; Germany, 302,871USD; France, 258,753USD.

2.4 The development of China Life Insurance Company Limited

According to the market research of China life insurance market, China Life Insurance Company Limited (short as China Life) is the largest life insurance company in China. The top 3 life insurance companies in China are China Life Insurance Company, China Ping An Life Insurance Company and China Pacific Life Insurance Company. The ranking of the life insurance companies is based on the insurance ratios of the companies, there are mainly 6 ratios, including market size, capital capacity, compensation reserve ratio, profitability, liquidity, and operating stability.

According to the report on 2012, China Life's market share and profit ranked the first in life insurance market, its compensation reserve ratio also ranked the first, the liquidity ratio ranked the 4th and stability ratio ranked the 7th among all the life insurance company in China[10].

China Life has the longest history among insurance companies in China, it was originally founded in 12th October 1949 which was 20 days after New China was founded. At the very beginning, there were only two insurance businesses: mandatory insurance and voluntary insurance, the mandatory insurance were mainly railway, ship, and aircraft passengers getting hurt in accidents insurances and the voluntary insurance included employee group life insurance[11] and simple life insurance[12]. Until 1958, the total life insurance premium was 0.141 billion RMB with 3 million insured person using employee group life insurance and 1.8 million insured person using simple life insurance. While in 1959, China State Council announced to stop insurance business, the China Life Insurance company and other insurance businesses were all stopped running.

[10] Information from baidujingyan: http://jingyan.baidu.com/article/ceb9fb10f6b0fd8cad2ba0d5.html

[11] Employee group life insurance: one life insurance for a group with one contract.

[12] Simple life insurance: it a low premium, without physical examination life insurance for works with low income. It was firstly applied in United Kingdom 1850s, once was a main part in China's life insurance, but now it was almost unused.

After 20 years in 1979, State Council approved to recover insurance industry step by step. China Life Insurance Company started to run again. From 1982 to 1995, the average growth of China Life's business increased 40% every year. From 1996 to 1998, China Life's marketing team increased from about 40 thousand people to over 200 thousand people, the insurance premium increased from 19.2 billion RMB to 54.0 billion RMB, China Life became the biggest insurance company in China.

In 2000, China Life decided to reform as a shareholding company. 2002, it first joint the Fortune Global 500. 2003, it was listed in New York Stock Exchange and Hong Kong Stock Exchange. 2007, it succeed listed in Shanghai Stock Exchange A-share. Thus it became the first insurance company listed in 3 stock exchange market.

In 2010, China Life's market share in life insurance was about 37.2%. It has the largest marketing team, distributed in all provinces, cities (except Taiwan), and towns with over 4,800 branches, 15,000 sales outlets, 716,000 individual agents and 12,600 group insurance sellers. Till the end of 2008, China Life got over 120 million valid individual and group life insurance contracts, annuity contracts and long-term health insurance policies, had provided over 600 million services to customers.

In the year 2013, China Life has received 326.3 billion RMB insurance premium, increased 1.1% comparing to last year. The percentage of renewal insurance premiums in long-term insurance premium is over 60%, the investment income has increased 93% from last year, the total profit increased 124% comparing to last year.[13]

2.5 Ratio analysis of China Life

The financial ratio analysis is very important to an insurance company, it can reflect the capital quality and the capital adequacy of the company, and these two ratios are what the regulatory cares the most. Many of the ratios will be published to the public, good ratios can give confidence to the public and reduce the risk of bankruptcy.

[13] The data are from the China Life 2013 Interim Results.

2.5.1 Horizontal common-size analysis

The main income of an insurance company is the premium income, the growth rate of the premium income can reflect the development of the insurance company, and can somehow reflect the information of the market share in the area of insurance market.

We set the data of the year 2009 as the benchmark, in this way we can compare the change of the premium income of China Life over time.

Table 2.2 is the premium income of China Life from year 2009 to 2013. In the table we list the total premium income, long-term premium, and the renewal premium[14]. As we know the long-term insurance is risker than the short-term insurance, so the long-term premium income is higher than the short-term premium income.

Table 2.2 Insurance premium income of China Life (million RMB)

	2009	2010	2011	2012	2013
Total insurance premium	275,970	318,229	318,252	322,742	326,290
Long-term insurance first year premium	156,476	175,277	147,721	126,111	114,993
Renewal premium	105,429	127,977	154,729	180,199	190,727

Source: Annual Performance of China Life (2009 to 2013)

In order to do the horizontal analysis, we should first divided the correspond items of each year to the items in year 2009. The results are shown in Table 2.3.

Table 2.3 Horizontal analysis of China Life (%)

	2009	2010	2011	2012	2013
Total insurance premium	100.0	115.3	115.3	116.9	118.2
long-term insurance first year premium	100.0	112.0	94.4	80.6	73.5
Renewal premium	100.0	121.4	146.8	170.9	180.9

From the table we can see that the total insurance premium is almost always increasing from 2009 to 2013 even though the growth rate decreased very much since the year 2010. On the other hand, the long-term first year premium income was decreasing since year 2010, and the renewal premium income was increasing every year. That's because of the policy change in the year 2010, China Life was trying to decrease

[14] Renewal premium: it is the subsequent premium paid by the insured to insurer, in order to keep the policy in operation.

the proportion of long-term first year premium to the total premium and to increase the proportion of renewal premium. Because in this way, the total premium income will stay at the same level as usual. And the long-term insurance will be more attractive to the customers, since the price of first-year premium was lower.

2.5.2 Solvency ratio

The solvency ratio is the value of net assets (its value equals to total assets minus total liability) to net premium written (equals to gross premium written minus the premium ceded to reinsurers), it can reflect the ability of an insurance company to repay its debt. In another word, the insurance company should have enough capital to cover the potential risk and its business range. Many countries set the minimum solvency ratio as 100%, some require 150% (the minimum requirement of solvency ratio in China is 150%). Table 2.4 is the solvency ratio of China Life from 2009 to 2013.

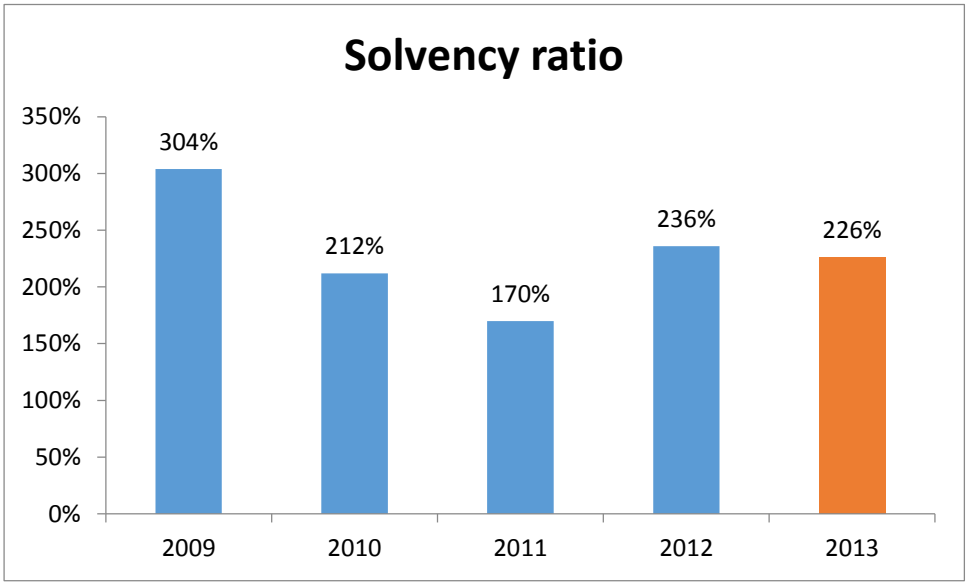
Table 2.4 Solvency ratio of China Life (%)

	2009	2010	2011	2012	2013
Solvency ratio	304	212	170	236	226

Source: Annual Performance Report of China Life (2009 to 2013)

The percentage change will be clearer in the Figure 2.1.

Figure 2.1 Solvency ratio of China Life



Generally, the solvency ratio of China Life was high than 150%, above the required level in China.

From 2009 to 2011, China Life had put a lot of capital into the expansion of its business, another reason is because of the market capital volatility.

In order to keep the solvency ratio at a higher but stable level, China Life had issued 30 billion RMB subordinated term bonds in the end of 2011, and 38 billion RMB subordinated term bond in 2012.

Usually it is better to keep the solvency ratio at a stable level, it is more important for the company to do so than to have a higher and higher ratio. The lager number of the ratio means the less profit from the company, because they always keep the money in hand, with very less investment, and this will prevent the company from developing.

2.5.3 Assets quality

The assets quality of an insurance company can be measured by its equity ratio and debt assets ratio. A suitable equity ratio or debt assets ratio can ensure the ability of the company to repay its debt, and also make most use of its assets scale and the debt leverage effect[15]. The equity ratio is total equity to total assets, debt assets ratio is the total debt to total assets.

Table 2.5 is the assets, debt, and equity of China Life from 2009 to 2013.

Table 2.5 Assets, liability, and equity of China Life (million RMB)

	2010	2011	2012
Equity	210,475	193,388	223,101
Liability	1,200,104	1,390,519	1,675,815
Total assets	1,410,579	1,583,907	1,898,916

Source: Annual Report of China Life (2010 to 2012)

We can then calculate the equity ratio and the debt assets ratio and make a graph for it.

The equity ratio and debt assets ratio of China Life from 2010 to 2012 are shown in Table 2.6.

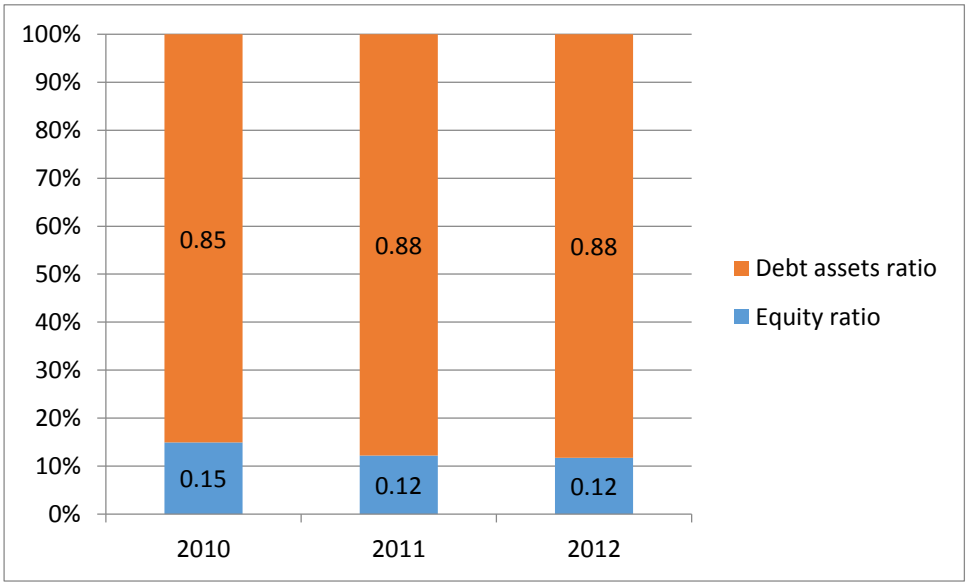
[15] Debt leverage effect: the increase proportion of debt to total assets to raise money can receive more profit after tax, than using equity to raise money.

Table 2.6 Equity ratio and Debt assets ratio of China Life

	2010	2011	2012
Equity ratio	0.15	0.12	0.12
Debt assets ratio	0.85	0.88	0.88

We can find that most of the capital raised of China Life were from its debt issued, average debt assets ratio was 0.87. As we know from the debt leverage effect, China Life will benefit from its high debt assets ratio, for its relative low tax cost than other companies. In China, China Life Insurance Company Limited is the largest and has the longest history in all life insurance companies. It is very easy for China Life to raise money from debt, and they are willing to lend money from outside, and they are not worry about the risk of bankruptcy, because it is too big to fail. The figure below can show us the debt leverage change of China Life. Figure 2.2 can show us the debt leverage change of China Life from 2010 to 2012.

Figure 2.2 Debt leverage change of China Life



2.5.4 Business develop speed

The business develop speed of an insurance company can be expressed by the premium growth rate. The premium growth rate is the increased of premium of this year to the premium of last year. To increase the business income is part of the company's operating goal. The rapid growth of business income will extend the proportion of its

market share, increase the value of its brand and increase its asset scale. And all the advantage can directly or indirectly increase the solvency ability of this company.

But the business growth speed can also increase the management cost and decrease the quality of business.

In fact the premium growth rate had already be shown at the part of Horizontal analysis. Table 2.7 is the premium income of China Life from 2009 to 2013.

Table 2.7 Premium income of China Life (million RMB)

	2009	2010	2011	2012	2013
Premium income	275,970	318,229	318,252	322,742	326,290

Source: Annual Performance Report of China Life (2009 to 2013)

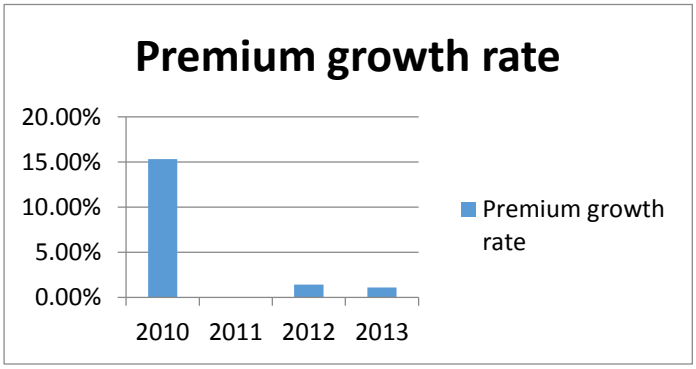
The Premium growth rate is in Table 2.8. Because we only get 5 years' premium income, so we can just make the premium growth for 4 years.

Table 2.8 Premium growth rate of China Life (%)

	2010	2011	2012	2013
Premium growth rate	15.31	0.01	1.41	1.10

We can find that in 2011, the growth rate of premium is only 0.01%, which is the lowest one. In 2011, the China Life's individual insurance decreased 0.3% (from 302,781 million RMB to 302,012 million RMB), group insurance decreased 7.4% (from 473 million RMB to 438 million RMB). Only the short-term insurance business got an increase of 5.5% (from 14,975 million RMB to 15,802 million RMB). The China Life was still adjusting its business structure in 2011 to be adapted to market demands. The figure below is the premium growth rate of China Life from 2010 to 2013, in the year 2011, because of the growth rate is only 0.01%, so it can't be seen on the figure. The premium growth rate of China Life from 2010 to 2013 is shown on figure 2.3.

Figure 2.3 Premium growth rate of China Life



2.5.5 Business quality

The business quality means the level of satisfaction of the customers to the insurance business, usually it contains the quality of counter service and the efficiency of repaying service. The quality of insurance business can be reflected by the cancellation rate[16]

The action of surrender means a loss of the insurance company and a shock to the stability of the firm, as most of the insurance contracts are medium and long term business. It is also a loss for the policyholder, he may lose a part of his premium, as the fee for cancel the contract in advance. If there is a lot of action of surrender, it means there must be some questions with the products and service from the insurance company.

The cancellation rate of China Life is shown on Table 2.9.

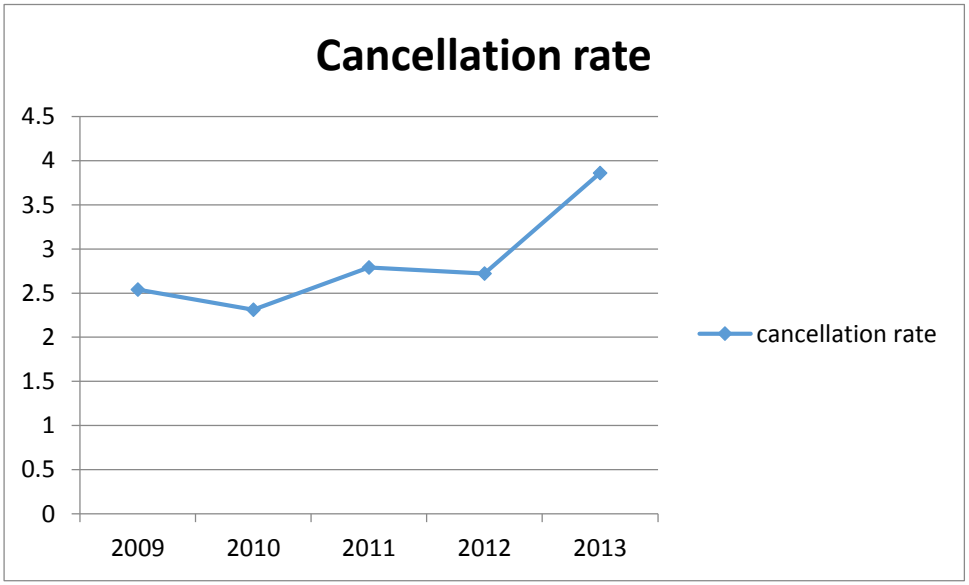
Table 2.9 Cancellation rate of China Life (%)

	2009	2010	2011	2012	2013
Cancellation rate	2.54	2.31	2.79	2.72	3.86

Source: Annual Performance Report of China Life (2009 to 2013)

Let's compare the change of cancellation rate though Figure 2.4.

Figure 2.4 Cancellation rate of China Life



[16] Cancellation rate: it is the surrender value divided the remaining value of premium reserves and the premium income. The lower of this ratio means the higher quality of the company's business.

The cancellation rate can reflect the satisfaction of customers to their insurance products and service, customers may cancel its insurance contracts because they may have a bad expectation of the insurance company, such as the expectation of default risk and risk of bankruptcy. Generally, the cancellation rate increased since 2010 to 2013, in 2013 it was 3.86%. In 2013, China's insurance industry faced the competition from other financial industry and the pressure of developing, large-scale maturity benefit payment and cancellation.

The net profit of China Life was decreasing over time, the net profit in 2010 was 33,811 million RMB, in 2011 it was 18,491 million RMB and in 2012 it was 11,272 million RMB, even though the premium income was increasing (small degree), the asset impairment loss[17] was increasing every year (from 1,734 million RMB in 2010 to 31,052 million RMB in 2012). That's why China Life's net profit was decreasing, and it could be part of the reason why the cancellation rate was increasing.

2.5.6 Operation capacity

Operation capacity means the efficiency of an insurance company to manage its assets. The operation capacity can be reflect by return on shareholders' equity (ROE), ROE is the net profit to shareholders' equity. The higher of ROE means the higher operation capacity of the company. The table below is the net profit and total shareholders' equity of China Life from 2010 to 2012.

Table 2.10 Net profit and total equity of China Life (million RMB)

	2010	2011	2012
Net profit	33,811	18,491	11,272
Shareholders' equity	210,475	193,388	223,101

Source: Annual report of China Life (2010 to 2012)

The ROE ratio of China Life is shown on Table 2.11.

[17] Asset impairment: Assets are said to be impaired when their net carrying value (acquisition cost minus accumulated depreciation) is higher than the recoverable amount. The loss is the difference between net carrying value and recoverable amount.

Table 2.11 ROE of China Life

	2010	2011	2012
ROE	0.161	0.096	0.051

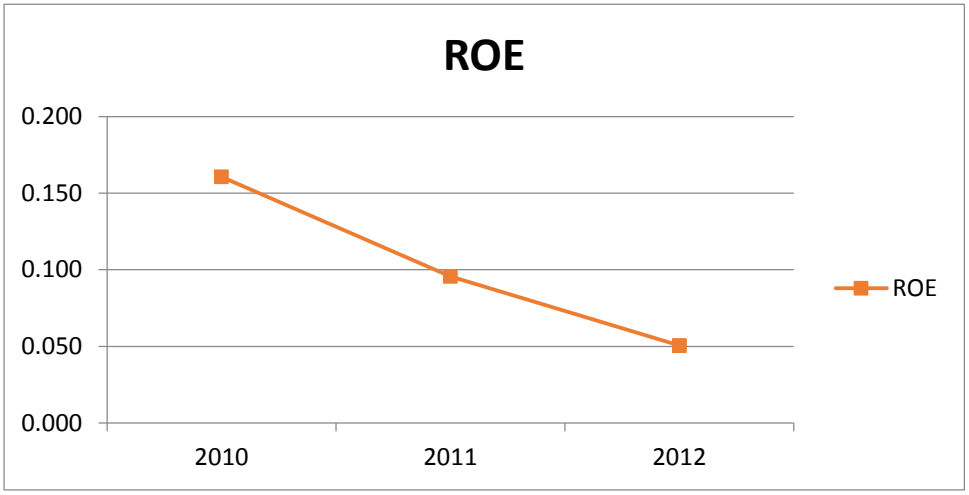
It is obvious that the ROE ratio was decreasing from 2010 to 2012, as the shareholders' equity were increasing while the net profit was decreasing. ROE was decreasing means the amount of dividend to shareholders was decreasing, which might influence the market share of China Life.

The earning per share of China Life from 2010 to 2012 were 1.19 RMB, 0.65 RMB and 0.39 RMB, respectively.

In 2013, the net profit of China Life was 24,765 RMB, increased 123.9% comparing to year 2012. The financial situation of China Life was getting better, because of the decrease of asset impairment loss (from 31,043 RMB to 3,803 RMB), and small decrease of commission charge and management cost. In the year 2013, the earning per share was 0.88 RMB, increased 0.49 RMB than last year. China Life still provided a large share of the insurance market.

The figure 2.5 is the ROE ratio of China Life from 2010 to 2012.

Figure 2.5 ROE of China Life



2.5.7 Profitability

Usually, the profitability ratio of an insurance company can be reflect by its operating profit ratio and return on investment ratio. The operating profit ratio is the operating profit to operating revenue, the higher of this ratio means the higher ability

for the firm to gain profit though operating, which means though the premium income to the insurance company. The return on investment ratio is the net investment income this year to the investment assets this year. Usually the insurance company will invest their extra capital into money market or capital market, in order to keep the assets profitability ratio at a higher level.

Table 2.12 is the operating profit and total operating revenue of China Life from 2010 to 2012.

Table 2.12 Operating profit and total operating revenue (million RMB)

	2010	2011	2012
Operating profit	41,011	20,546	10,955
Total revenue	388,791	385,388	405,379

Source: Annual report of China Life (2010 to 2012)

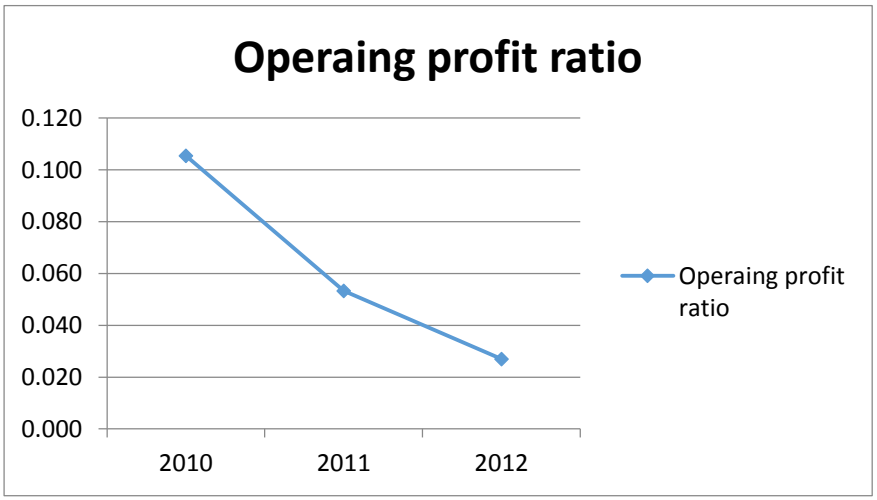
With the data we can get the operating profit ratio of China Life from 2010 to 2012, which is shown on Table 2.13.

Table 2.13 Operating profit ratio

	2010	2011	2012
Operating profit ratio	0.105	0.053	0.027

It is obvious that this ratio was decreasing from 2010 to 2012, even though the total revenue increased in the year 2012. As we mentioned, the reason why operating profit was decreasing was the increase of asset impairment loss. And the decrease of operating profit caused the decrease of insurance market share of China Life. Figure 2.6 is the operating profit ratio of China Life from 2010 to 2012.

Figure 2.6 Operating profit ratio



The investment income is a main part of the total revenue, the efficiency of investment business of China Life can be shown by its return on investment ratio. Table 2.14 is can show us the investment assets from 2007 to 2012.

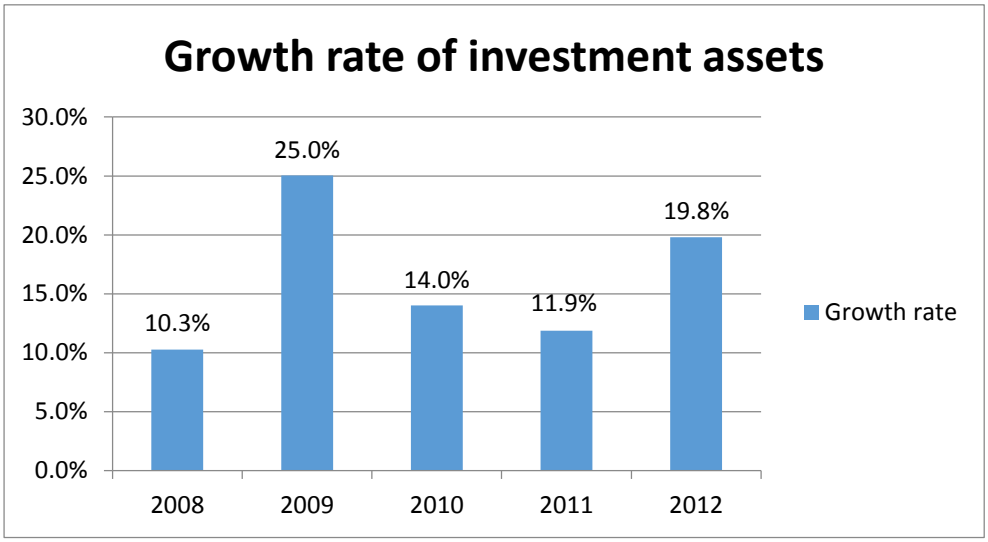
Table 2.14 Investment asset of China Life (million RMB)

	2007	2008	2009	2010	2011	2012
Investment assets	850,209	937,403	1,172,145	1,336,245	1,494,969	1,790,838

Source: Annual performance of China Life (2009 to 2012)

The investment assets was increasing every year, we can check the growth rate of investment assets by Figure 2.7.

Figure 2.7 Growth rates of investment assets



In 2009, many of the national companies recovered from financial crisis in 2008 stably, but the stock market was very unstable at that time. In order to lower down the risk in investment business, China Life had decreased its proportion securities assets (from 61.4% in 2008 to 49.7%), increased the equity assets (from 8.0% in 2008 to 15.3%) and the fixed time deposit (from 24.4% in 2008 to 29.4%). The total investment profit increased 95.6% than in the year 2008.

Table 2.15 can show us the growth rate of total investment profit of China Life from 2009 to 2013.

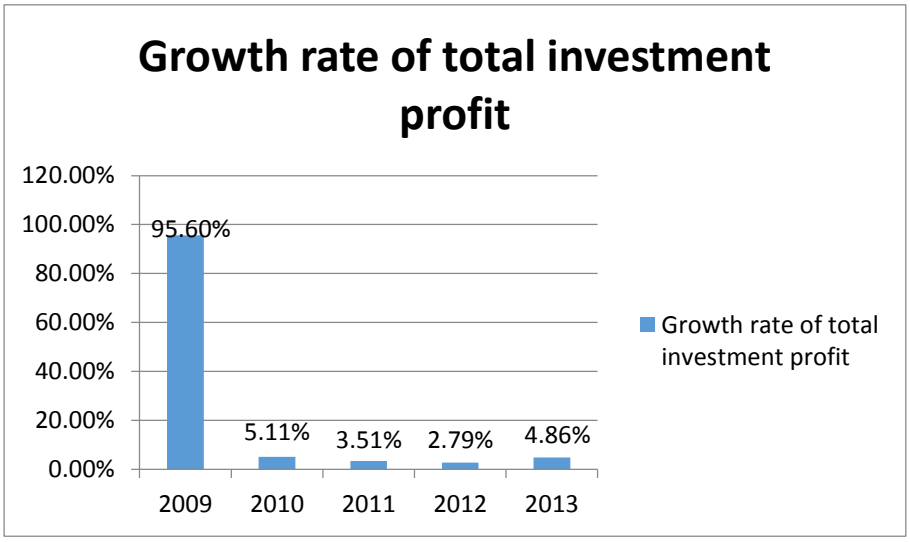
Table 2.15 Growth rate of total investment profit (%)

	2009	2010	2011	2012	2013
Investment growth rate	95.60	5.11	3.51	2.79	4.86

Source: Annual performance of China Life (2009 to 2013)

We can show the growth rate of investment profit though Figure 2.8.

Figure 2.8 Growth rate of total investment profit



In 2009, the business of investment of China Life had got a great success, because of the proper structure change of investment assets as well as the low investment income in 2008.

As the base amount of investment profit in 2009 was so big, that it was hard to get the similar growth rate of 2009. Anyway, the investment profit of China Life was increasing these years, from 2011 to 2013, China Life was trying to increase the amount of bond securities investment assets and fixed time deposit, at the same time decreasing the amount of equity investment assets.

As the premium income market becomes more and more saturated, the investment business in insurance industry nowadays is very competitiveness. The insurance companies are trying to change their premium structure as well as investment assets, in order to get as much profit as possible.

2.5.8 Conclusion

In general, the financial situation of China Life is losing its value from the life insurance market. Some of its ratios are decreasing over years, such as premium growth rate, ROE ratio, and the operating profit ratio, which is a bad signal to the public, even

though China Life is still the largest life insurance company in China. Just after the year 2011, some of the ratios of China Life started to recover, but the growth rate of these ratios are relatively very low.

The development of China Life is likely to stuck at present level, it seems that it is so hard to have any improvement in the life insurance market. We can hope that there will be some innovation happened in insurance service and products in China Life Insurance Company Limited.

3. Multiple Choice Decision-Making Method Description

Decision making is very easy when considering single criterion problems, as we just need to choose the alternative with the higher utility. However, when we evaluate the alternatives with multiple criteria, decision making may be complicated with many problems, such as wrights of criteria, conflicts among criteria.

In order to deal with multiple criteria decision-making (MCDM) problems, we need to apply some specialized methods, to help us to evaluate the possible alternatives and since to determine the best alternative.

In this chapter, we will introduce four methods, which is concerning MCDM problems. We will first determine the basic function of these methods, then in details how they work, and the calculation processes. This chapter applied the theories and ideas from TZENG and Huang (2011).

3.1 Analytic hierarchy process (AHP)

The procedures of MCDM can be summarized in five main steps as follows (Dubois and Prade 1980):

Step 1: Define the nature of the problem;

Step 2: Construct a hierarchy system for its evaluation;

Step 3: Select the appropriate evaluation model;

Step 4: Obtain the relative weights and performance score of each criteria with respect to each alternative.

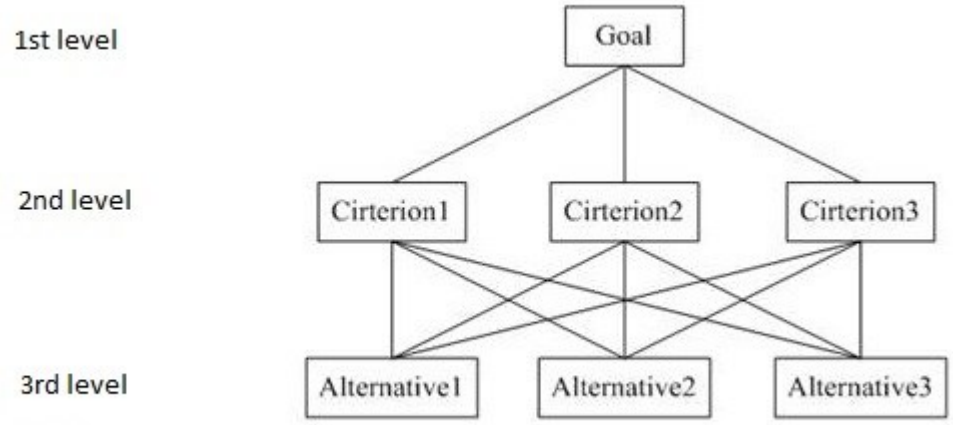
Step 5: Determining the best alternative according to the synthetic utility values, which are the aggregation value of relative weights, and performance scores corresponding to alternatives.

The analytic hierarchy process (AHP) was suggested as the basic method to derive the relative weights, when dealing with MCDM problems. AHP was proposed by Saaty

(1977, 1980) to model subjective MCDM problems in a hierarchical system. There are four main steps in AHP.

Step 1: Set up the hierarchical system by decomposing the problem into a hierarchy interrelated elements. Figure 3.1 is a three level hierarchy, which is shown as below.

Figure 3.1 A three level hierarchy



Step 2: Compare the set of n attributes pairwise according to their relative importance weights.

Step 3: Synthesize the individual subjective judgment and estimate the relative weight.

Step 4: Aggregate the relative weights of the elements to determine the best alternatives.

The n criteria can be denoted by $a_1, a_2, \ldots, a_n$ and the weights are denoted as $w_1, w_2, \ldots, w_n$, then the pairwise comparisons can be expressed as the following equation:

$$A = \begin{bmatrix} a_{11} & \cdots & a_{1j} & \cdots & a_{1n} \\ \vdots & & \vdots & & \vdots \\ a_{i1} & \cdots & a_{ij} & \cdots & a_{in} \\ \vdots & & \vdots & & \vdots \\ a_{n1} & \cdots & a_{nj} & \cdots & a_{nn} \end{bmatrix}, \tag{3.1}$$

where $a_{ij} = 1/a_{ji}$ and $a_{ij} = a_{ik}/a_{jk}$. In realistic situation, the value of w_i/w_j is usually unknown. So, the problem for the AHP is to find S_{ij} as that $S_{ij}=w_i/w_j$.

We can derive the weight matrix be represented as:

$$W = \begin{bmatrix} w_1/w_1 & \cdots & w_1/w_j & \ldots & w_1/w_n \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ w_i/w_1 & \cdots & w_i/w_j & \ldots & w_i/w_n \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ w_n/w_1 & \ldots & w_n/w_j & \ldots & w_n/w_n \end{bmatrix}, \ \vec{w} = \begin{bmatrix} w_1 \\ \vdots \\ w_j \\ \vdots \\ w_n \end{bmatrix} \quad (3.2)$$

Well, as the results from Saaty's (1994) conclusion, the absolute number from 1-9 scale is the approximation to the ratio w_i/w_j. Where: 1 – indifference, 3 – weak preference, 5 – strong preference, 7 – very strong preference, 9 – absolute preference. The even number of points (2, 4, 6, and 8) can also be chosen if there is more precise preference. The positive preference is expressed as S_{ij} which is in the interval (1;9]. For the impact of the negative preference, they belong to the interval $S_{ij} \in \left(\frac{1}{9}; 1\right]$. And for the diagonal elements S_{ij}=1, the inverse S_{ij}=1/S_{ji}. The strength of the preference can be show on Table 3.1.

Table 3.1 Ratio scale in the AHP

Intensity	1	3	5	7	9	2, 4, 6, 8
Linguistic	Equal	Moderate	Strong	Demonstrated	Extreme	Intermediate value

Source: TZENG and Huang (2011).

The weighted geometric mean is one of the simplest methods to determine the normalized scales w_i:

$$w_i = \frac{v_i}{\sum_i^N v_i} = \frac{\left[\prod_j^N s_{ij}\right]^{\frac{1}{N}}}{\sum_i^N \left[\prod_j^N s_{ij}\right]^{\frac{1}{N}}} \quad (3.3)$$

To continue, we need to check the consistency of the criteria. We need the matrix to be consistent, so that the criteria can fulfill the condition of transitivity. The consistency can be evaluated by consistency ratio (CR), where the consistency value is considered CR≤ 0.1, Saaty (1994) define the consistency ratio as

$$CR = \frac{CI}{RI}, \quad (3.4)$$

where

$$CI = \frac{(\lambda_{max} - n)}{(n-1)}, \quad (3.5)$$

the number λ_{max}, the eigen number is the characteristic number of matrix. It can be determined in many ways. One possible way to compute it is as

$$\lambda_{max} = \frac{1}{N}\sum_{1}^{N}(S \times \vec{w})_i / w_i. \quad (3.6)$$

Where $\vec{w}$ is vector and $(S \times \vec{w})_i$ is the i^{th} criterion of vector. RI is the random index, the value of it is determined by the number of the criteria, which is shown on Table 3.2.

Table 3.2 Random index (RI)

n	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45

Source: Saaty (1994)

So far the weights of the criteria are calculated. The weights here we mean the local weights. The local weights are calculated by the geometric mean formula, where for each group of criteria (sub criteria) the relative weights are estimated. The global weights happen when we consider the possibility of the local sub criteria. The formula for the global weights to be calculated is as below:

$$w_{ij} = w_i \times w_j, i = 1, \dots, n; j = 1, \dots, n. \quad (3.7)$$

Where w_i represents the criteria of the local weights, and w_j represents the criteria of local sub criteria. The sum of the global weights should be equal to 1.

3.2 Simple additive weighting method (SAW)

The simple additive weighting method (SAW) is a method to deal with multiple criteria decision-making (MCDM) problems. Because of its simplicity, it is the most popular method in MCDM.

The best alternative can be described as below:

$$A^* = \{u_i(x)|max_i u_i(x)|i = 1,2,\cdots,n\}, \quad (3.7)$$

where A^* stands for best alternative; $u_i(x)$ denotes the utility of the i^{th} alternative and $i = 1, 2, \dots, n$.

Also, the utility of the i^{th} alternative can be calculated as

$$u_i(x) = \sum_{j=1}^{n} w_i r_{ij}(x) \quad (3.8)$$

where w_j denotes the weights of j^{th} criterion; $r_{ij}(x)$ is the normalized preferred ratings of i^{th} alternative with respect to the j^{th} criterion for all commensurable units; and all criteria are assumed to be independent. In addition, in the SWA method the normalized preferred ratings ($r_{ij}(x)$) of the i^{th} alternative with respect to j^{th} criterion can be define as:

- For benefit criteria (larger is better), $r_{ij}(x) = x_{ij}/x_j^*$, where $x_j^* = \max_i x_{ij}$, and it is clear $0 \leq r_{ij}(x) \leq 1$.
- For cost criteria (smaller is better), $r_{ij}(x) = x_j^*/x_{ij}$, where $x_j^* = \min_i x_{ij}$, also the interval for the value is from 0 to 1.

The way of normalization above is the most common one, in fact we can apply many other normalization methods to AHP method. We will introduce other methods to get the normalized value in the rest of this chapter (which will be appeared in VIKOR method and TOPSIS method).

With the value of the normalized criteria of each alternative and their weights, we can easily get the utility of each alternative. The best alternative for our customer is the one with the highest utility.

3.3 VIKOR method

The word "VIKOR" stands for VlseKriterijumska Optimizacijia I Kompromisno Resenje (VIKOR) method, it was used for multi-criteria optimization of complex systems. This method can determine the compromise ranking list, compromise solution, and the weight stability intervals for preference stability of the compromise solution obtained with the given weight. It shows us the multi-criteria ranking index based on the particular measure of "closeness" to the "ideal" solution (Opricovic, 1998).

If each alternative is evaluated according to each criterion function, the compromise ranking could be performed by comparing the measure of closeness to ideal alternative. In the model, the various J alternatives are denoted as $a_1, a_2, \ldots, a_j$.

For alternative a_j, the rating of the i^{th} aspect is denoted by f_{ij}. In another word, f_{ij} is the value of the i^{th} criterion function for the alternative a_j. n is the number or criteria.

There are several steps to reach the compromise ranking algorithm VIKOR:

a) Determine the best f_i^* and the worst f_i^- values of all criterion functions, $i = 1, 2, \ldots, n$. if the i^{th} function respects a benefit (the bigger the better) then:

$$f_i^* = \max_j f_{ij}, \qquad f_i^- = \min_j f_{ij}.$$

If the i^{th} function respects a loss (the less the better) then:

$$f_i^* = \min_j f_{ij}, \qquad f_i^- = \max_j f_{ij}.$$

The normalization formula for the positive elements and negative elements:

$$r_{ij} = (f_{ij} - f_i^-)/(f_i^* - f_i^-), \tag{3.9}$$

$$r_{ij} = (f_i^* - f_{ij})/(f_i^* - f_i^-). \tag{3.10}$$

b) Compute the value S_j and R_j, $j = 1, 2, \ldots, J$, by the relations, for S_j if the i^{th} function respects a benefit then:

$$S_j = \sum_{i=1}^{n} w_i(f_{ij} - f_i^-)/(f_i^* - f_i^-). \tag{3.11}$$

If the i^{th} function respects a loss then:

$$S_j = \sum_{i=1}^{n} w_i(f_i^* - f_{ij})/(f_i^* - f_i^-). \tag{3.12}$$

For R_j, it is the best utility of criteria for each alternative:

$$R_j = \max_i\left[w_i(f_i^* - f_{ij})/(f_i^* - f_i^-)\right] \tag{3.13}$$

Where w_i are the weights of criteria, which is the preference of the elements.

c) Compute the value of the alternative to our customers Q_j, $j = 1, 2, \ldots, J$, by the formula

$$Q_j = v(S_j - S^*)/(S^- - S^*) + (1 - v)(R_j - R^*)/(R^- - R^*) \tag{3.14}$$

where

$$S^* = \min_j S_j,\ S^- = \max_j S_j,\ R^* = \min_j R_j,\ R^- = \max_j R_j,$$

and v stands for the weight of the strategy of "the majority of criteria" (or "the maximum group utility"), usually the value of v can be 0, 0.25, 0.5, 0.75, and 1. While v equals to 0 means to pick the best alternative according to the worst criteria, v equals to 1 mean to pick the best alternative according to the average of all the criteria. The

value of Q_j we get from $v = 0$ means the distance from the ideal solution, while the value we get from $v = 1$ means the utility to our customer. When the value of v is between 0 and 1, the results of Q_j contains both the distance from the ideal one and utility to our customer.

3.4 TOPSIS method

The word "TOPSIS" is short for the Technique for Order Preferences by Similarity to an Ideal Solution, this method was proposed by Hwang and Yoon (1981). The basic principle is to choose the best alternative that have the shortest distance from the ideal solution and the longest distance to the negative-ideal solution.

Usually a TOPSIS method contains 6 parts:

1) Calculate the normalized matrix for the criteria. The formula for the normalized value r_{ij} is as

$$r_{ij} = f_{ij} \Big/ \sqrt{\sum_{j=1}^{J} f_{ij}^{\,2}}, j = 1, \ldots, J; i = 1, \ldots, n, \tag{3.15}$$

where f_{ij} denotes the value of the criterion function.

2) Calculated the weighted normalized decision matrix. The weighted normalized value v_{ij} is calculated as

$$v_{ij} = w_i \times r_{ij}, j = 1, \ldots, J; i = 1, \ldots, n, \tag{3.16}$$

where w_i stands for the weights value of the i^{th} criteria.

3) Determine the ideal solution A^*

$$A^* = \{v_1^*, \ldots, v_n^*\},$$

for the positive criterion the $v_j^* = \max_j v_{ij}$, while for the negative criterion the $v_j^* = \min_j v_{ij}$.

The negative-ideal solution A^-

$$A^- = \{v_1^-, \ldots, v_n^-\},$$

for the positive criterion the $v_j^- = \min_j v_{ij}$, and for the negative criterion the $v_j^- = \max_j v_{ij}$.

4) Calculate the separation measures, the separation of each alternative from ideal solution is as below

$$D_j^* = \sqrt{\sum_{i=1}^{n}\left(v_{ij} - v_j^*\right)^2}, j = 1, \ldots, J. \quad (3.17)$$

The separation of negative-ideal solution is as below

$$D_j^- = \sqrt{\sum_{i=1}^{n}\left(v_{ij} - v_j^-\right)^2}, j = 1, \ldots, J. \quad (3.18)$$

5) Calculate the relative closeness to ideal solution. The relative closeness of the alternative a_j with the respect to A^* is defined as

$$C_j^* = D_j^-/(D_j^* + D_j^-), j = 1, \ldots, J. \quad (3.19)$$

6) Rank the preference order and pick the best alternative solution.

3.5 Comparing SAW, VIKOR and TOPSIS

In order to solve the MCDM choice, we applied three methods (SAW method, VIKOR method, and TOPSIS method).

Always the first step of all the methods are normalization of the criteria, the SAW method and VIKOR method use linear normalization (different formula), while TOPSIS method uses vector normalization, which is more complicated than the other ones. All the methods need the information of the weights of criteria (which is calculated by Saaty method).

The aggregation approach of these methods are different. The SAW method is very simple just sum up the weighted value of all criteria, it figures out the utility of all alternative. The VIKOR method introduces the aggregation function of the distance from the ideal solution, but as the change of the value *v* the results will contains utility of the alternative and the distance from the ideal solution, or just the utility of the alternative. The TOPSIS method introduces an aggregation function of the distance from the ideal solution and the negative-ideal solution, the distance in TOPSIS are simply summed in Formula (3.19), without considering their relative importance.

The solution of SAW method is the one with the highest utility, the best alternative in the VIKOR method is the closest to the ideal solution, while the highest ranked

alternative by TOPSIS is the best in terms of the ranking index, which means it is not always the closest from the ideal solution.

4. Application of MCDM Choices of Health Insurance Products

In this chapter, we will introduce a 30 years old man, Mr. Li, he gets a problem with choosing the best health insurance products from three life insurance companies. The character of the products, which he chooses from each companies, are somehow similar. Our job is to help Mr. Li to choose the best health insurance product for him, by applying the methods, which we have introduced in the third chapter.

In this chapter, there will contain many formulas, calculations, and also comments. Most of the calculations are computed from Microsoft EXCEL, we will also present the calculating process from EXCEL, in order for a better understanding.

4.1 Introduction of our customer and insurance products

Our customer, Mr. Li, is 30 years old and has a successful career and happy family. He wish to design himself a health secure plan, which can prevent him from serious diseases, death and such risk. And also he wants to increase the value of money on hand to prepare for his pension funds. In simple words, he wants to have a health insurance product.

Mr. Li cares about the premium of the contract, the claim he will get when he is in disease, the payment period of the contract and also the valid age of the contracts. Regardless of these criteria, Mr. Li will also consider about the credit of the insurer, and its comments from customers, when buying the contracts.

The most reliable 3 life insurance companies in China are China Life, PingAn Life, and Pacific Life. Mr. Li would like to choose the product from one these 3 companies, which may have the most benefit for him.

China Life product[18]: the China Life can provide a "whole life serious diseases insurance" for Mr. Li. Its basic insured amount is 300 thousand RMB, the payment period can be 10 years and 20 years, which is depend on the customer, and valid year for the contract will last for the life time of the customers. For 10 years premium payment, every year Mr. Li will pay 16,350 RMB. Once the contract is settled up, there will be a 180 days' observation to the customer. It means within 180 days when the contract become effective, any serious diseases or death happened to the customer, the customer will receive the total amount of his premium payment (without interest), and the contract will end.

After 180 days' observation, when the customer the first time suffers any serious diseases (which are stated in the contract), and it is proved by the doctor. The customer will receive 300 thousand RMB and the contract finished.

During 180 days' observation, when the customer suffers some specific diseases the insurance company will not be responsible for this situation. After 180 days' observation, when the customer first time suffers a specific disease the insurance company will pay 60 thousand RMB to him. This kind of payment will be only once, the contract is still effective for the customer.

After 180 days' observation, if the customer die for some event, the insurance company will pay 300 thousand RMB to the beneficiary, the contract will end.

The claim for serious diseases or death will be only paid for one aspect, and the payment will be only once.

The contact is available for the man after 28 days born, and the age blow 60 with a healthy body. The payment for the premium can be once or installment, if it was once, the amount of the payment will be equal to the basic insured amount.

The basic information of criteria of the product from China Life can be listed as Table 4.1.

[18] The information of the product from China Life is based on the description from its official website. Thesituation is the same for the products from PingAn Life and Pacific Life.

Table 4.1 Criteria information of China Life product

	Premium (RMB/year)	Payment period (year)	Basic insured amount (thousand RMB)	Observation days	Valid age
China Life	16,350	10	300	180	Until death

PingAn Life: the PingAn Life company can provide a "health security plan" for Mr. Li. The plan has a basic insured amount of 100 thousand RMB, the payment period can be 5 years and 10 years, and the valid age for the consumer is 60. For the 5 years payment, the annual amount for the customer will be 17,880 RMB, once the contract is settled up, there will be a 90 days' observation. Within the days of observation, any diseases that are stated on the contract or death happened to the customer will end the contract and the customer will receive the sum amount of his premium payment (without interest payment).

After 90 days' observation, if the customer suffers any diseases that are stated on the contract, he will receive 200 thousand RMB, and the contract will end.

After 90 days' observation, if the customer die for some reason, the beneficiary will receive 200 thousand RMB from the insurance company. The contract will end.

If the customer is alive when he is 60 years old, he will receive 100 thousand RMB and the contract will end.

The contract is available for all people, the payment will be only once.

The criteria information of the product from PingAn Life is listed on Table 4.2.

Table 4.2 Criteria information of PingAn Life product

	Premium (RMB/year)	Payment period (year)	Basic insured amount (thousand RMB)	Observation days	Valid age
PingAn Life	17,880	5	100	90	60

Pacific Life: the Pacific Life company can provide Mr. Li "serious diseases insurance". The contract's basic insured amount is 200 thousand RMB, and its payment period is usually 5 years, 10 years, 15 years, 20 years, and 30 years. Its valid year is the life time of the insured. And it is suitable for the people born 30 days to 60 years old.

After the contract is settled up, there will be a 90 days' observation for the customer. Within the 90 days, if the customer suffers any serious diseases which is stated on the contract or death, the contract will end and the customer will receive the total amount of premium he paid previously.

If the customer takes a 20 years payment contract, he will pay 7,220 RMB every year.

After 90 days' observation, if the customer suffers any serious diseases that are stated on the contract, he will receive 200 thousand RMB, and the contract will end. if the customer will need to have an operation immediately, the insurance company can offer 100 thousand RMB right now, and the rest 100 thousand RMB will be paid back after.

After 90 days' observation, if the customer suffers some specific diseases that are stated on the contract, he will receive 30% of the basic insured amount (that is 60 thousand RMB) immediately, the contract is still available. The contract doesn't limit the time of the claim for specific diseases, so if the customer suffers one disease at his 50s and another one at his 60s he will receive totally 120 thousand RMB immediately.

After 90 days' observation, if the customer die for some event, the insurance company will pay the beneficiary 200 thousand RMB, the contract will end.

If the immediate claim for the specific diseases is over 100 thousand RMB, the insurance company will pay only 100 thousand RMB. When the accumulate claim is equal to the basic insured amount, the contract will end.

The basic information of the criteria of the product from Pacific Life can be expressed on Table 4.3

Table 4.3 Criteria information of Pacific Life product

	Premium (RMB/year)	Payment period (year)	Basic insured amount (thousand RMB)	Observation days	Valid age
Pacific Life	7,220	20	200	90	Until death

So far, we have the criteria information for the three health insurance products from China Life, PingAn Life, and Pacific Life.

We can make a simple comparison of these three products by putting the three products together, as Table 4.4.

Table 4.4 Basic information of all alternatives

	Premium (RMB/year)	Payment period (year)	Basic insured amount (thousand RMB)	Observation days	Valid age
China Life	16,350	10	300	180	Until death
PingAn Life	17,880	5	100	90	60
Pacific Life	7,220	20	200	90	Until death

We can find that Pacific Life have the lowest amount of premium payment every year, the shortest observation days, and the longest valid age. It seems that the best choice for Mr. Li is from Pacific Life. But if we take into account of the payment period, or the basic insured amount, the products from China Life or PingAn life might be better than the product from Pacific Life in some way.

Now, we meet the problem of multiple choice decision-making. In order to deal with the problem we will need to apply the methods we have mentioned in the previous chapter.

4.2 Saaty method (weights calculation)

Before applying any methods to the MCDM problem, we should first distinguish which elements (criteria) are positive to Mr. Li (the larger the better to our customer), and which ones are negative (the less the better for our customer). As Mr. Li is a normal man, so we can quickly figure out that the positive elements are: Basic insured amount and the valid age, the negative elements are: premium, payment period, and the observation days.

For better understanding with the character of criteria, we may need to make a new table for the alternatives. Table 4.5 can show us the basic information of all criteria with preference for each alternative.

Table 4.5 Basic information with preference matrix

	min[19]	min	max	min	max
	Premium (RMB/year)	Payment period (year)	Basic insured amount (thousand RMB)	Observation days	Valid age
China Life	16,350	10	300	180	100[20]
PingAn Life	17,880	5	100	90	60
Pacific Life	7,220	20	200	90	100

Before applying AHP method, we may need some basic acknowledge about Table 4.5. We get three alternatives: Product from China Life, PingAn Life, and Pacific Life; and 5 criteria: premium, payment period, basic insured amount, observation days, and valid age.

The first step for us is to make the pairwise matrix for all criteria. According to ratios on Table 3.1, we can make a simple distinguish of the strength preference of our customer to these 5 criteria. The results are shown as: premium-3, payment period-1, basic insured amount-5, observation days-1/3, and valid age-1. (The preference for each criterion we give here is just one possible way, in the real life the results should be depend on the character of the customers) And according to the preference to each criterion, we can make the pairwise matrix for all criteria, as shown on Table 4.6.

Table 4.6 Pairwise matrix for criteria

	Premium	Payment period	Basic insured amount	Observation days	Valid age
Premium	1	3	3/5	9	3
Payment period	1/3	1	1/5	3	1
Basic insured amount	5/3	5	1	9	5
Observation days	1/9	1/3	1/9	1	1/3
Valid age	1/3	1	1/5	3	1

[19] "min" means the item of the row is the less the better for our customer, and "max" means the opposite to "min".

[20] For easy calculating, we assume the valid age until death is equal to 100. The same way for the valid age of Pacific Life.

After we get the pairwise matrix, we can use Formula (3.3) to get the weights of each criterion. The results are shown on Table 4.7.

Table 4.7 Weights of criteria

	Premium	Payment period	Basic insured amount	Observation days	Valid age
Weights	0.30	0.10	0.46	0.04	0.10

In order to make the calculation process clear, here we list out the part of the process of calculating the weights of premium.

According to Formula (3.3), we should first get all the v_i. If we say v_1 stands for premium, then the process of calculating v_1 is as

$$v_1 = \left(1 \times 3 \times \frac{3}{5} \times 9 \times 3\right)^{\frac{1}{5}} = 2.17,$$

by the same function we can get the value of v_2, v_3, v_4, and v_5. As the results, $v_2 = 0.72$, $v_3 = 3.27$, $v_4 = 0.27$, and $v_5 = 0.72$ (v_2, v_3, v_4, and v_5 stand for payment period, basic insured amount, observation days, and valid age). After we get all the v_i, we can get the weight of each criterion. Here the weights for premium w_1

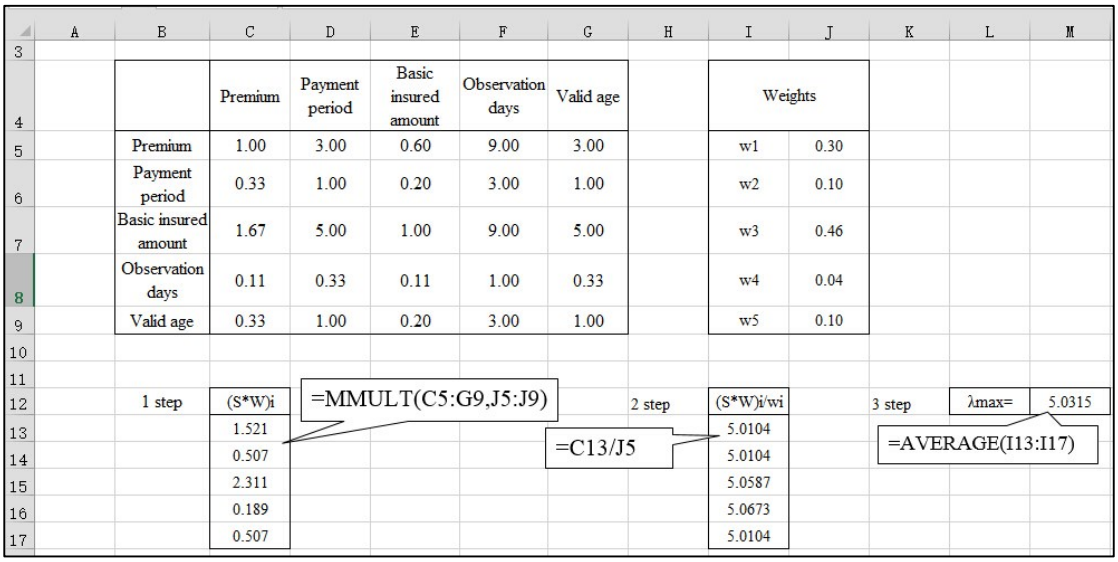
$$w_1 = \frac{v_1}{(v_1+v_2+v_3+v_4+v_5)} = \frac{2.17}{(2.17+0.72+3.27+0.27+0.72)} = 0.30,$$

using the same formula we can get the value of w_2, w_3, w_4, and w_5, $w_2 = 0.10$, $w_3 = 0.46$, $w_4 = 0.04$, and $w_5 = 0.01$ (w_2, w_3, w_4, and w_5 stand for the weights of payment period, basic insured amount, observation days, and valid age).

In fact, the weights of these 5 criteria are weights of local sub criteria, here we do not consider about the weights of these 3 insurance companies. Usually, our consumer will have a preference to some specific insurance company, there will be a priority for that company. For example, in China people always want to have an insurance contract from China Life, that's because of China Life's history and its position over years.

When we get the weights of each criterion, we may need to check the consistency (value of *CR*) of the criteria, and if we need to check the value of *CR*, we should first know the characteristic number of the matrix - λ_{max}. By using Formula (3.6), we can get the value of λ_{max}. The process of calculating λ_{max} is as Figure 4.1.

Figure 4.1 Process of computing λ_{max} in SAW



Here we have $\lambda_{max} = 5.0315$. According to Formula (3.5), we can have the value of $CI = 0.0079$. As we have 5 criteria, the random index $RI = 1.12$.

So far, we have all the information to reach the value of CR. By using Formula (3.4), we get the value of consistency ratio $RI = 0.007$. As our value of RI is smaller than 0.1, we may think that the elements (criteria) fulfil the condition of transitivity, which means we can use the value of weights for criteria we computed before in other methods.

4.3 Simple additive weighting method

When we know the weights of each criterion, we can figure out which alternative is the best for our customer, by using Simple additive weighting (SAW) method.

The first step of SAW method is to get the normalized matrix of criteria for each alternative.

According to the information in the introduction of SAW method in the third chapter and the data from Table 4.2, we can get the normalized matrix for the criteria, as shown on Table 4.5.

The normalization for SAW method can be various, here we just present one possible way. In the rest of this chapter, we will apply other normalization method into SAW method, and compare the difference between them.

Table 4.8 Normalized matrix of SAW method

	min	min	max	min	max
	Premium (RMB/year)	Payment period (year)	Basic insured amount (thousand RMB)	Observation days	Valid age
China Life	0.44	0.50	1.00	0.50	1.00
PingAn Life	0.40	1.00	0.33	1.00	0.60
Pacific Life	1.00	0.25	0.67	1.00	1.00

After we get the normalized value of all the criteria for each alternative, by using Formula (3.8) and the value of weights from Saaty method, we can have the access to the utility of each alternative. The results are as Table 4.9.

Table 4.9 Utility by SAW method

China Life	PingAn Life	Pacfic Life
0.923	0.560	0.648

The value of product from China Life is 0.923, which is much higher than the other two. As the SAW method is to determine the utility of each alternative, so we may think that the product from China Life has the most utility to our customer, Mr. Li. If we only use one method for Mr. Li, we may recommend him to buy the health insurance product from China Life.

4.4 VIKOR method

The normalization of VIKOR method is somehow similar to the normalization of SAW method. We will first need to distinguish the positive elements and the negative elements, the difference between these two methods is the way of their calculating.

From Table 4.5, we can first figure out the best f_i^* and the worst f_i^- values of all criterion functions (both negative elements and positive elements) according to first step in the introduction of VIKOR method.

We will show Table 4.5 again for better understanding of the calculation process of VIKOR method.

Table 4.5 Basic information with preference matrix

	min	min	max	min	max
	Premium (RMB/year)	Payment period (year)	Basic insured amount (thousand RMB)	Observation days	Valid age
China Life	16,350	10	300	180	100
PingAn Life	17,880	5	100	90	60
Pacific Life	7,220	20	200	90	100

By using Formula (3.9) and Formula (3.10), we can get the normalization for VIKOR method, the results is as Table 4.7.

Table 4.10 Normalization matrix for VIKOR method

	min	min	max	min	max
	Premium (RMB/year)	Payment period (year)	Basic insured amount (thousand RMB)	Observation days	Valid age
China Life	0.14	0.67	1.00	0.00	1.00
PingAn Life	0.00	1.00	0.00	1.00	0.00
Pacific Life	1.00	0.00	0.50	1.00	1.00

Now we have the normalization value of the criteria for each alternative. The next step is to calculate the value of S_j, according to Formula (3.11) and Formula (3.12). At the same time we can compute the value of R_j, according to Formula (3.13). The results are shown on Table 4.11.

Table 4.11 Value of S_j and R_j for VIKOR method

	Sj	Rj
China Life	0.669	0.46
PingAn Life	0.139	0.10
Pacific Life	0.670	0.30

Once we get the value of S_j and R_j, we can have the access to compute the value of each alternative Q_j.

From the Formula (3.14), we should first figure out the value of max S_j, min S_j, max R_j, and min R_j, which values are shown on Table 4.12.

Table 4.12 Max and min values of S_j and R_j

	Sj	Rj
min	0.139	0.101
max	0.670	0.457

The value of Q_j is also depend on the value of v (weight of the strategy of "the majority of criteria"). Here we have the value of v = 0, 0.25, 0.50, 0.75, and 1, the results of Q_j is on the Table 4.13.

Table 4.13 Value of alternatives

	v	0	0.25	0.5	0.75	1
China Life	$Q1$	100.00%	99.93%	99.86%	99.79%	99.72%
PingAn Life	$Q2$	0.00%	0.00%	0.00%	0.00%	0.00%
Pacific Life	$Q3$	56.91%	67.68%	78.45%	89.23%	100.00%

If we choose the best from the worst (that means when v = 0), we can find that China Life is the best choice for the customer. But when choose the best from the average level (which means when v = 1), the Pacific Life is the best choice for our customer. China Life can be also in the decision list, for the results are so close.

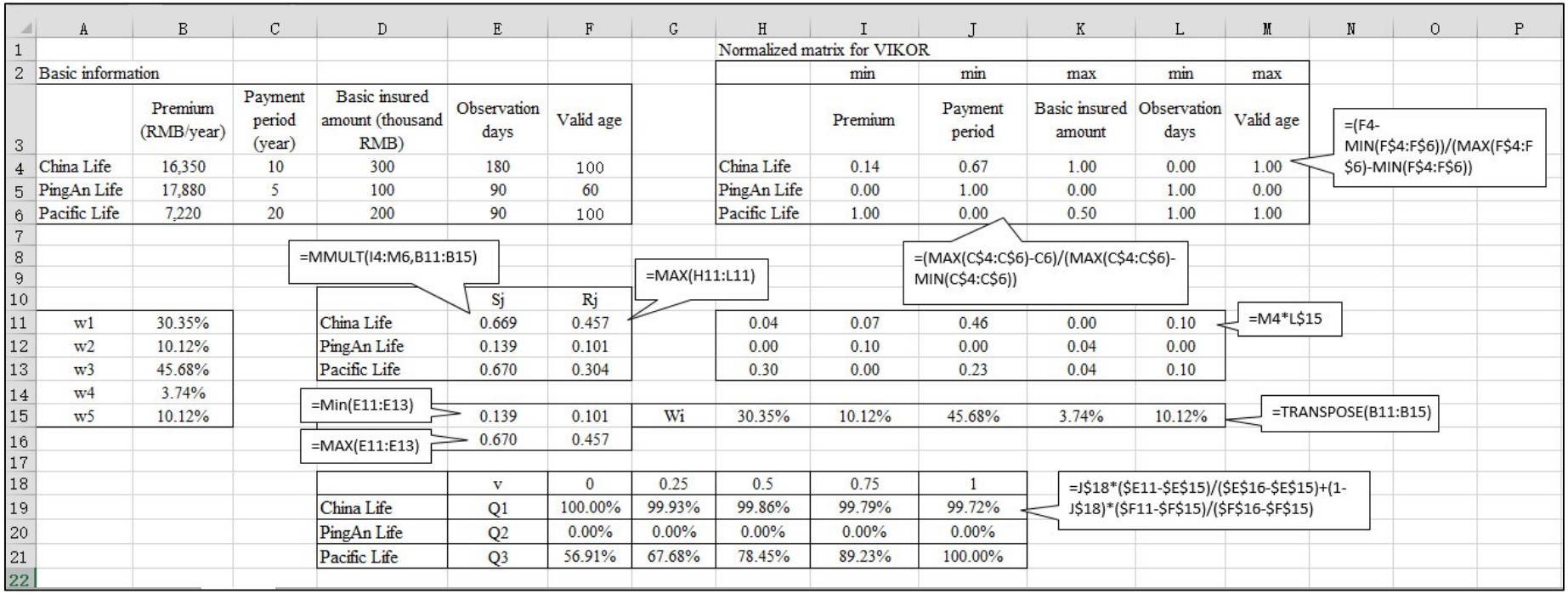
From the Table 4.13, we can find that most of the time China Life is better than other companies. But the value of PingAn Life is very low whatever the value of v takes, this could because of the products we choose from PingAn Life is not very comparable to the other ones. If we just take into account of VIKOR method for our customer, Mr. Li, we will not consider the product from PingAn Life, both the products from China Life and Pacific Life is possible him.

The calculating process is shown on Table 4.14.

4.5 TOPSIS method

The basic principle of TOPSIS method is to choose the alternative that have the shortest distance from the ideal solution and the farthest distance from the negative-ideal solution.

Table 4.14 Calculation process of VIKOR method



The first step of TOPSIS method is to get the normalized value of the criteria. As we know the normalization of VIKOR method is linear, TOPSIS method uses vector normalization.

The way how to get the normalized value r_{ij} for TOPSIS method is shown by Formula (3.15), the results are as following Table 4.15.

Table 4.15 Normalization matrix of TOPSIS method

	min	min	max	min	max
	Premium (RMB/year)	Payment period (year)	Basic insured amount (thousand RMB)	Observation days	Valid age
China Life	0.6467	0.4364	0.8018	0.8165	0.6509
PingAn Life	0.7072	0.2182	0.2673	0.4082	0.3906
Pacific Life	0.2856	0.8729	0.5345	0.4082	0.6509

When we know the normalized value of criteria for each alternative, we can calculated the weighted normalized value v_{ij}, by using Formula (3.16). Table 4.16 is the value of weighted normalized value v_{ij}.

Table 4.16 Weighted normalization matrix of TOPSIS method

	min	min	max	min	max
	Premium (RMB/year)	Payment period (year)	Basic insured amount (thousand RMB)	Observation days	Valid age
China Life	0.1963019	0.0441576	0.3662206	0.0304992	0.0658611
PingAn Life	0.2146714	0.0220788	0.1220735	0.0152496	0.0395167
Pacific Life	0.0866850	0.0883152	0.2441470	0.0152496	0.0658611

The next step is to determine the ideal and negative-ideal solutions. According to the third step in the description of TOPSIS method, we can figure out the value of A^* and A^-. The results are as following table 4.17.

Table 4.17 Ideal and negative-ideal Solution of TOPSIS method

	min	min	max	min	max
A^*	0.08668	0.02208	0.36622	0.01525	0.06586
A^-	0.21467	0.08832	0.12207	0.03050	0.03952

Now we have the value of ideal and negative-ideal solutions of the weighted normalized value v_{ij}, we can use these numbers to calculate the separation measures, by using the Formula (3.17) and Formula (3.18).

The results are as following table 4.18.

Table 4.18 Ideal and negative-ideal solution of TOPSIS method

		D_j^*	D_j^-
China Life	$A1$	0.11285	0.25018
PingAn Life	$A2$	0.27692	0.06797
Pacific Life	$A3$	0.13889	0.17947

The last step is to calculate the distance of the alternative to the ideal solution and negative-ideal solution. By using Formula (3.19), we can get the relative closeness of each alternative, the results are shown on Table 4.19.

Table 4.19 Relative closeness of alternative of TOPSIS method

		C_j
China Life	A1	0.6891
PingAn Life	A2	0.1971
Pacific Life	A3	0.5637

From the results, we can find that China Life is the best one among these three companies, but it doesn't mean that the product from China Life is always the closest to ideal solution or the farthest to the negative-ideal solution. The results concern the average distance from the ideal solution and the negative-ideal solution.

If we just consider the results from TOPSIS method, we will choose the product from China Life as the best solution for our customer, Mr. Li.

The calculation process is shown on Table 4.20.

4.6 SAW method with different normalization method

As we mentioned in the previous part, the SAW method can apply different normalization method for the criteria. In this part, we will apply the normalization method of VIKOR method and the TOPSIS method.

We can first use the normalization matrix of VIKOR method, as shown on Table 4.10, and apply it into the process of SAW method.

Table 4.20 Calculation process of TOPSIS method

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Basic information									w1	w2	w3	w4	w5		
2		min	min	max	min	max			Weights	0.3035	0.1012	0.4568	0.0374	0.1012		
3		Premium (RMB/year)	Payment period (year)	Basic insured amount (thousand RMB)	Observation days	Valid age				=B4^2						
4	China Life	16,350	10	300	180	100			A1	267,322,500	100	90,000	32,400	10,000		
5	PingAn Life	17,880	5	100	90	60			A2	319,694,400	25	10,000	8,100	3,600		
6	Pacific Life	7,220	20	200	90	100			A3	52,128,400	400	40,000	8,100	10,000		
7								sum + squared		25,281	23	374	220	154		=SQRT(SUM(N4:N6))
8																
9	Normalization	rij	0.6467225	0.4364358	0.8017837	0.8164966	0.6509446		vij	0.1963019	0.0441576	0.3662206	0.0304992	0.0658611		
10			0.7072415	0.2182179	0.2672612	0.4082483	0.3905667			0.2146714	0.0220788	0.1220735	0.0152496	0.0395167		=G10*N$2
11		=B6/J$7	0.2855863	0.8728716	0.5345225	0.4082483	0.6509446			0.0866850	0.0883152	0.2441470	0.0152496	0.0658611		
12																
13			min	min	max	min	max	=MAX(N9:N11)							=(N9-G$14)^2	
14	A+	=MIN(J9:J11)	0.0867	0.0221	0.3662	0.0152	0.0659		Dj+	0.1129	0.01202	0.00049	0.00000	0.00023	0.00000	
15										0.2769	0.01638	0.00000	0.05961	0.00000	0.00069	
16	A-	=MAX(J9:J11)	0.2147	0.0883	0.1221	0.0305	0.0395			0.1389	0.00000	0.00439	0.01490	0.00000	0.00000	=(N11-G$16)^2
17								=MIN(N9:N11)	Dj-	0.2502	0.00034	0.00195	0.05961	0.00000	0.00069	
18	Cij	A1	0.68914							0.0680	0.00000	0.00439	0.00000	0.00023	0.00000	
19		A2	0.19708	=J18/(J18+J15)				=SQRT(SUM(K19:O19))		0.1795	0.01638	0.00000	0.01490	0.00023	0.00069	
20		A3	0.56374													

Table 4.10 Normalization matrix for VIKOR method

	min	min	max	min	max
	Premium (RMB/year)	Payment period (year)	Basic insured amount (thousand RMB)	Observation days	Valid age
China Life	0.14	0.67	1.00	0.00	1.00
PingAn Life	0.00	1.00	0.00	1.00	0.00
Pacific Life	1.00	0.00	0.50	1.00	1.00

By using Formula (3.8) and the value of weights from Saaty method, we can now figure out the utility of each alternative, as shown on Table 4.21.

Table 4.21 Utility of SAW method with normalization from VIKOR method

China Life	PingAn Life	Pacific Life
0.66895	0.13853	0.67044

Now we can see that the results is totally different from the original one (China Life is much better than the other two companies), the product from Pacific Life have the best utility to our customer.

We can also apply the normalization method of TOPSIS method. First we will need the normalization matrix of TOPSIS method, as shown on Table 4.15.

Table 4.15 Normalization matrix of TOPSIS method

	min	min	max	min	max
	Premium (RMB/year)	Payment period (year)	Basic insured amount (thousand RMB)	Observation days	Valid age
China Life	0.6467	0.4364	0.8018	0.8165	0.6509
PingAn Life	0.7072	0.2182	0.2673	0.4082	0.3906
Pacific Life	0.2856	0.8729	0.5345	0.4082	0.6509

Then we will need to redo the process of calculation the utility for each alternative again, by using Formula (3.8) and the value of weights from Saaty method. The results are shown on Table 4.22.

Table 4.22 Utility of SAW method with normalization from TOPSIS method

China Life	PingAn Life	Pacific Life
0.70304	0.41359	0.50026

We can found that the results change again, still the product from China Life is the best one for our customer, but the gap from Pacific Life or PingAn Life is closer.

Even though SAW method is very simple for us to use, but the results from SAW method will be various from different normalization methods, and so we will be not able to get a proper answer to our customer. We will need to decide just one method of normalization for SAW method, when we need to apply it. Because once we change the way of normalization, we will get a different answer to the original one.

4.6 Comparison of SAW, VIKOR, and TOPSIS

From the analysts' point of view, the comparison of methods we are applied is very important. Because each method get their disadvantages and advantage. Sometimes it is not the best for us to decide the best alternative from just one method, we need to compare the method together, and then figure out the best alternative for our customer.

In order to do the comparison, we first need to list the results from the three methods together (as for the results of SAW method, we will apply only the original one), as shown on Table 4.23.

Table 4.23 Comparison of the methods

		VIKOR					TOPSIS	SWA
		0	0.25	0.5	0.75	1		
China Life	A1	100.00%	99.93%	99.86%	99.79%	99.72%	68.91%	92.34%
PingAn Life	A2	0.00%	0.00%	0.00%	0.00%	0.00%	19.71%	56.05%
Pacific Life	A3	56.91%	67.68%	78.45%	89.23%	100.00%	56.37%	64.81%

We can find that just in one situation in VIKOR, when $v = 1$, the product from Pacific Life is better than the product from China Life. In other situations, the product from China Life is always the best. If we do not consider the preference of companies

of our customer, Mr. Li, we may conclude that the product from China Life is better than the product from the other two companies.

But from the analysts' point of view, we should have a preference to different methods. In another words, there should be a weights on each method. We should determine the weight of each method first, and then compare the results we get. The weights given are shown on Table 4.24.

Table 4.24 Consideration of Weights of methods

		VIKOR					TOPSIS	SWA
		0	0.25	0.5	0.75	1		
China Life	A1	100.00%	99.93%	99.86%	99.79%	99.72%	68.91%	92.34%
PingAn Life	A2	0.00%	0.00%	0.00%	0.00%	0.00%	19.71%	56.05%
Pacific Life	A3	56.91%	67.68%	78.45%	89.23%	100.00%	56.37%	64.81%
Weights of methods		0.1	0.05	0.1	0.05	0.3	0.3	0.1

The sum value of weight of each method is equal to 1. Then we can calculate the average value of product from each company, the results are shown on Table 4.25.

Table 4.25 Value of alternative with weights of methods

	China Life	PingAn Life	Pacific Life
Average	89.80%	11.52%	74.77%

The average value of each alternative is the sum value of the weighted value of each method. Still we can find that China Life is the best one among these three companies, and when we consider the market position of China Life (the best life insurance company in China), we can determine that the product of China Life is the best one of these three companies.

In the previous discussion, we didn't consider the preference to companies of our customer, Mr. Li. If there are weights of Companies from our customer, the results we get might be different.

Assuming that Mr. Li has a very good impression on Pacific Life insurance company. Under this condition, we can set the preference (weights) of the three companies as Table 4.26.

Table 4.26 Weights of companies

	W of companies		Average
China Life	A1	0.3	89.80%
PingAn Life	A2	0.2	11.52%
Pacific Life	A3	0.5	74.77%

As we can see that Pacific Life has the best weights. Now we can compute the value of each alternative to our customer, Mr. Li. The results are shown on Table 4.27.

Table 4.27 Value of alternatives when considering Weights of companies

	Final
China Life	26.94%
PingAn Life	2.30%
Pacific Life	37.39%

From the table, we can see that indeed the results changed. Now the best product for our customer is from Pacific Life.

In this situation, the preference of companies are the local criteria, and the elements of the products are local sub criteria. From the analysis of Mr. Li's situation, we can find that the influence of weights to local criteria is more important than the weights of local sub criteria when we are solving the MCDM problem.

4.7 Conclusion

In this chapter, we have applied different methods in order to solve the MCDM problem in the area of health insurance products.

We introduced one method (Saaty method) to calculate the weights of criteria, and three methods (SAW method, VIKOR method, and TOPSIS method) to determine the best alternative. Each of the method gets their own way to normalized the criteria (linear normalization and vector normalization) and their own idea about the determination of the best alternative (some calculate the utility of the alternative, some figure out the distance of the alternative from the ideal one or from the negative-ideal one). Most of the times, in order to reach the really best alternative, we need to take into account of many methods (set the weights of methods) and also the preference of the companies (set the weights of the companies).

5. Conclusion

This thesis is focused on the multiple choice decision-making problems applied in insurance industry. We have introduced the character of MCDM problem, and the possible methods to solve it.

The main part is in chapter 4, there is solved the MCDM problem of health insurance in China market. We have introduced a 30 years old man, whose name is Li. He is a risk averse, and is looking for a health insurance product from the largest three life insurance companies. We have found that there are five possible criteria for him to choose the product, these criteria including the premium payment, payment period, the basic insured amount, the observation days, and the valid age.

We have used the analytic hierarchy process (AHP) method to get the weights of each criterion. And then we applied the value of the weights into other three methods in order to figure out the best alternative for our customer.

The simple additive weighting method is the relatively easier than the other two method. It can figure out the utility of each alternative to the customer, and as the results, the product from China Life is the best one for him. We have then applied VIKOR method, this method calculates the distance of the alternative from the ideal solution, and the results can be various if the value of v (weight of strategy) changes, as the results, the best products can be from China Life and also from Pacific Life. The last method we use is TOPSIS method, this method calculate the distance of the alternative from the best solution and from the negative-ideal solution. As the results, the best product for our customer is from China Life.

Finally, we have made a comparison of the results from each method, and we figure out that the best decision for our customer is to choose the product from Pacific Life (mainly because of the weights of companies).

In fact, there should be more methods for us to deal with the MCDM problem, such as the ELECTRE method, Gray relational method, and PROMETHEE method, and so on. There method are more professional, much more difficult than the ones we

use, and much more interesting. If we are facing some more complicated MCDM problems, such as when we need to consider more criteria, the conflict of the criteria is more complex, we may use these methods for better solutions.

Bibliography

a) Publications

EVANGELOS, Triantaphyllou. *Multi-Criteria Decision Making Methods: A Comparative Study*. 2000 ed. Berlin: Kluwer Academic Publishers, 2000. 318 p. ISBN 0-792-36-607-7.

TZENG, Gwo-Hshiung and Huang Jih-Jeng. *Multiple Attribute Decision Making: Methods and Applications.* London: Chapman & Hall/CRC, 2011. 349 p. ISBN 1-439-86-157-9.

SATTY, Thomas L. and L. Vargas. *Fundamentals of Decision Making and Priority Theory With the Analytic Hierarchy Process*. 1st ed. Pittsburgh: RWS Publications, 1994. 527 p. ISBN 978-0-9620-3176-2.

b) Electronic documents

ScienceDirect: *Compromise solution by MCDM methods: A comparative analysis of VIKOR and TOPSIS* [online]. [01.06.2014].
Available on: http://www.sciencedirect.com/science/article/pii/S0377221703000201

BaiduBaike: *China Life Insurance Company Limited* [online]. [01.03.2014].
Available on:
http://baike.baidu.com/view/174076.htm?fromtitle=%E4%B8%AD%E5%9B%BD%E4%BA%BA%E5%AF%BF&fromid=1537241&type=syn

China Life: *Home (about us)* [online]. [01.03.2014].
Available on: http://www.chinalife.com.cn/publish/yw/index.html

China Life: *History & Culture* [online]. [01.03.2014].
Available on: http://www.chinalife.com.cn/publish/yw/584/index.html

China Life: *Investor Relations (Presentations)* [online]. [01.03.2014]
Available on: http://www.e-chinalife.com/IRchannel/http/en/material.html

The People's Bank of China: *Regional financial operation report* [online]. [01.03.2014].
Available on: http://www.pbc.gov.cn/publish/zhengcehuobisi/601/index.html

List of Abbreviation

AHP	Analytic hierarchy process
MCDM	Multiple choice decision-making
ROE	Return on equity
SAW	Simple additive weighting
TOPSIS	Technique for Order Preferences by Similarity to an Ideal Solution
VIKOR	VlseKriterijumska Optimizacijia I Kompromisno Resenje

Herewith I declare that

- I am informed that Act No. 121/2000 Coll. – the Copyright Act, in particular, Section 35 – Utilization of the Work as a Part of Civil and Religious Ceremonies, as a Part of School Performances and the Utilization of a School Work – and Section 60 – School Work, fully applies to my diploma (bachelor) thesis;
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- I agree that the diploma (bachelor) thesis shall be archived in the electronic form in VSB-TUO's Central Library and one copy shall be kept by the supervisor of the diploma (bachelor) thesis. I agree that the bibliographic information about the diploma (bachelor) thesis shall be published in VSB-TUO's information system;
- It was agreed that, in case of VSB-TUO's interest, I shall enter into a license agreement with VSB-TUO, granting the authorization to utilize the work in the scope of Section 12(4) of the Copyright Act;
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Ostrava dated 11.07.2014

Liu Tao

List of annexes

Annex 1	Part of the information from balance sheet
Annex 2	Part of the information from income statement
Annex 3	Calculation process of λ_{max}
Annex 4	Calculation process of VIKOR method
Annex 5	Calculation process of TOPSIS method

Annex 1 Part of the information from balance sheet (million RMB)

	2010	2011	2012
Total liquidity assets	123,526	179,068	232,924
Total assets	1,410,579	1,583,907	1,898,916
Liability	1,200,104	1,390,519	1,675,815
Equity	210,475	193,388	223,101

Annex 2 Part of the information from income statement (million RMB)

	2010	2011	2012
Operating profit	41,011	20,546	10,955
Net profit	33,811	18,491	11,272

Annex 3 Calculation process of λ_{max}

	Premium	Payment period	Basic insured amount	Observation days	Valid age
Premium	1.00	3.00	0.60	9.00	3.00
Payment period	0.33	1.00	0.20	3.00	1.00
Basic insured amount	1.67	5.00	1.00	9.00	5.00
Observation days	0.11	0.33	0.11	1.00	0.33
Valid age	0.33	1.00	0.20	3.00	1.00

Weights	
w1	0.30
w2	0.10
w3	0.46
w4	0.04
w5	0.10

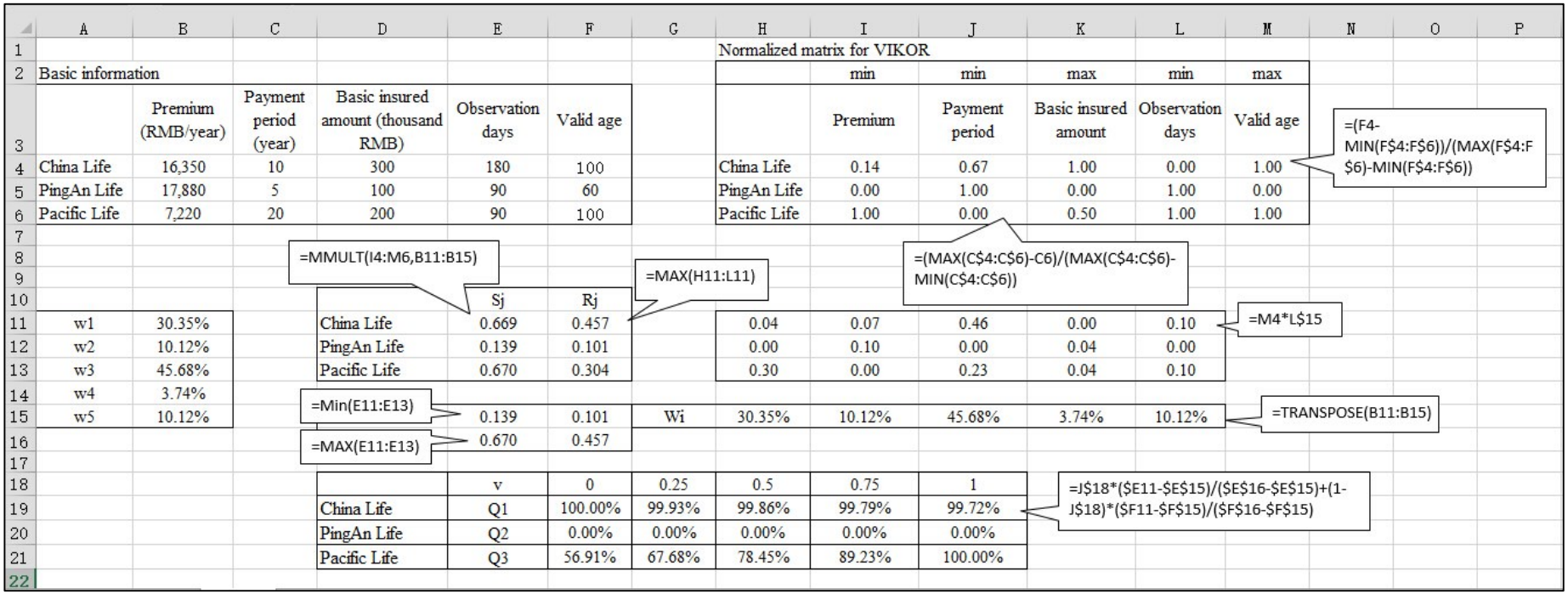
1 step (S*W)i	2 step (S*W)i/wi	3 step λmax= 5.0315
1.521	5.0104	
0.507	5.0104	
2.311	5.0587	
0.189	5.0673	
0.507	5.0104	

=MMULT(C5:G9,J5:J9)

=C13/J5

=AVERAGE(I13:I17)

Annex 4 Calculation process of VIKOR method



Basic information

	Premium (RMB/year)	Payment period (year)	Basic insured amount (thousand RMB)	Observation days	Valid age
China Life	16,350	10	300	180	100
PingAn Life	17,880	5	100	90	60
Pacific Life	7,220	20	200	90	100

Normalized matrix for VIKOR

	min	min	max	min	max
	Premium	Payment period	Basic insured amount	Observation days	Valid age
China Life	0.14	0.67	1.00	0.00	1.00
PingAn Life	0.00	1.00	0.00	1.00	0.00
Pacific Life	1.00	0.00	0.50	1.00	1.00

=(F4-MIN(F$4:F$6))/(MAX(F$4:F$6)-MIN(F$4:F$6))

=MMULT(I4:M6,B11:B15)

=MAX(H11:L11)

=(MAX(C$4:C$6)-C6)/(MAX(C$4:C$6)-MIN(C$4:C$6))

			Sj	Rj
w1	30.35%	China Life	0.669	0.457
w2	10.12%	PingAn Life	0.139	0.101
w3	45.68%	Pacific Life	0.670	0.304
w4	3.74%			
w5	10.12%			

0.04	0.07	0.46	0.00	0.10	=M4*L$15	
0.00	0.10	0.00	0.04	0.00		
0.30	0.00	0.23	0.04	0.10		

=Min(E11:E13)

=MAX(E11:E13)

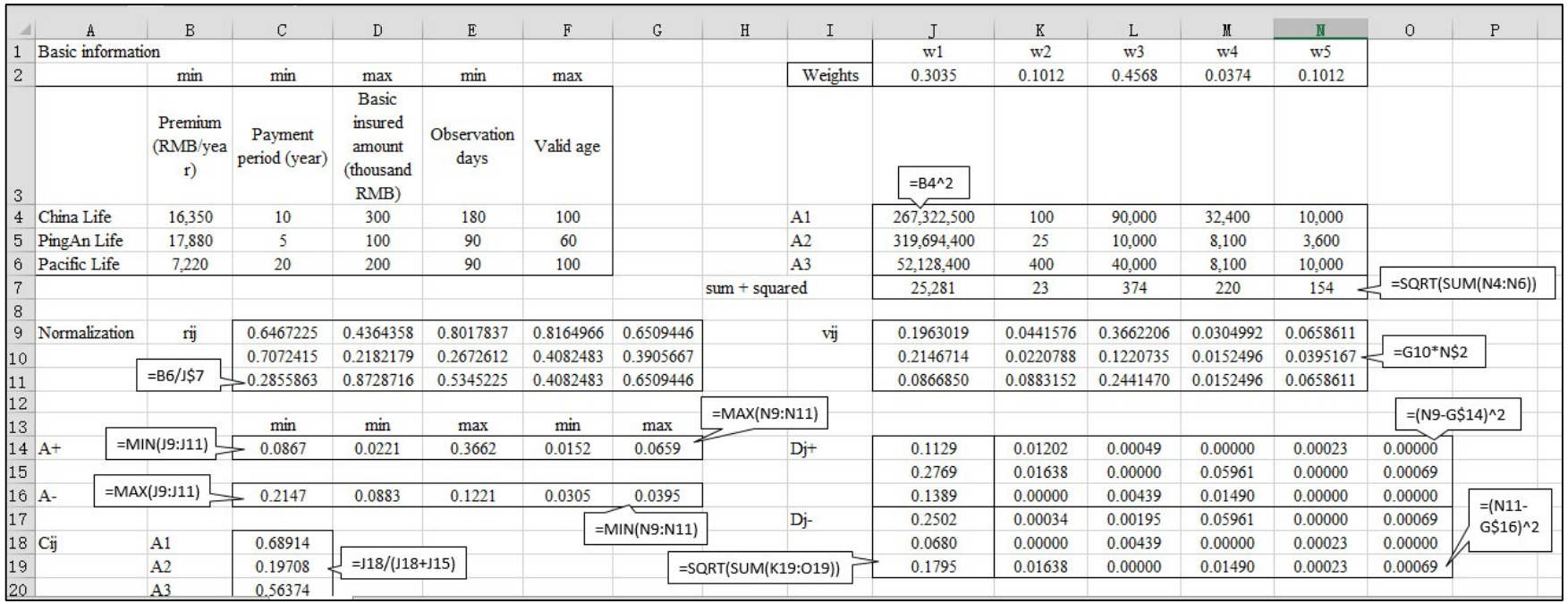
0.139	0.101	Wi	30.35%	10.12%	45.68%	3.74%	10.12%
0.670	0.457						

=TRANSPOSE(B11:B15)

	v	0	0.25	0.5	0.75	1
China Life	Q1	100.00%	99.93%	99.86%	99.79%	99.72%
PingAn Life	Q2	0.00%	0.00%	0.00%	0.00%	0.00%
Pacific Life	Q3	56.91%	67.68%	78.45%	89.23%	100.00%

=J$18*($E11-E15)/(E16-E15)+(1-J$18)*($F11-F15)/(F16-F15)

Annex 5 Calculation process of TOPSIS method



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Basic information									w1	w2	w3	w4	w5		
2		min	min	max	min	max			Weights	0.3035	0.1012	0.4568	0.0374	0.1012		
3		Premium (RMB/year)	Payment period (year)	Basic insured amount (thousand RMB)	Observation days	Valid age				=B4^2						
4	China Life	16,350	10	300	180	100			A1	267,322,500	100	90,000	32,400	10,000		
5	PingAn Life	17,880	5	100	90	60			A2	319,694,400	25	10,000	8,100	3,600		
6	Pacific Life	7,220	20	200	90	100			A3	52,128,400	400	40,000	8,100	10,000		
7								sum + squared		25,281	23	374	220	154		
8																
9	Normalization	rij	0.6467225	0.4364358	0.8017837	0.8164966	0.6509446		vij	0.1963019	0.0441576	0.3662206	0.0304992	0.0658611		
10			0.7072415	0.2182179	0.2672612	0.4082483	0.3905667			0.2146714	0.0220788	0.1220735	0.0152496	0.0395167		
11			0.2855863	0.8728716	0.5345225	0.4082483	0.6509446			0.0866850	0.0883152	0.2441470	0.0152496	0.0658611		
12																
13			min	min	max	min	max									
14	A+		0.0867	0.0221	0.3662	0.0152	0.0659		Dj+	0.1129	0.01202	0.00049	0.00000	0.00023	0.00000	
15										0.2769	0.01638	0.00000	0.05961	0.00000	0.00069	
16	A-		0.2147	0.0883	0.1221	0.0305	0.0395			0.1389	0.00000	0.00439	0.01490	0.00000	0.00000	
17									Dj-	0.2502	0.00034	0.00195	0.05961	0.00000	0.00069	
18	Cij	A1	0.68914							0.0680	0.00000	0.00439	0.00000	0.00023	0.00000	
19		A2	0.19708							0.1795	0.01638	0.00000	0.01490	0.00023	0.00069	
20		A3	0.56374													

=B6/J$7
=MIN(J9:J11)
=MAX(J9:J11)
=MAX(N9:N11)
=MIN(N9:N11)
=J18/(J18+J15)
=SQRT(SUM(K19:O19))
=SQRT(SUM(N4:N6))
=G10*N$2
=(N9-G$14)^2
=(N11-G$16)^2